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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication Tolerance

Application of Steam Cylinder Oil

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LUBRICATION

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Lubrication Tolerance

How The Principles Of Mechanics Affect The Choice Of Lubricants

TOLERANCE in machine design has to do with allowable leeway in size. In effect it is a plus or minus factor which the designing engineer is permitted to employ, with full assurance that the parts in question will function efficiently with respect to one another when the final assembly is put into operation. Tolerance must also be considered when lubrication recommendations are to be made.

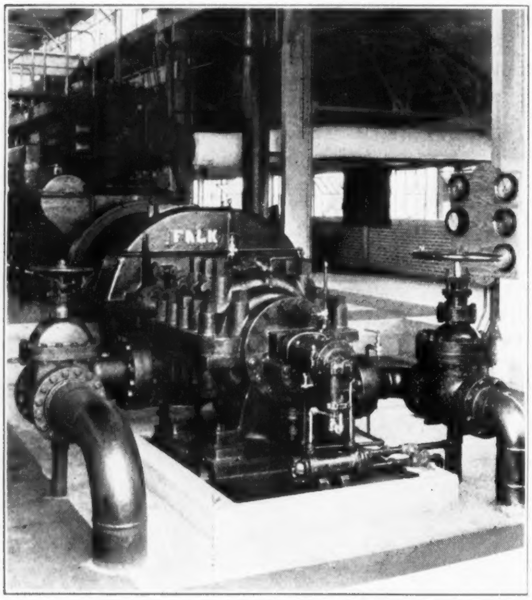
In the attainment of effective lubrication there are certain controlling factors which should be carefully studied before a lubricant is recommended for any installation; these include operating conditions and the design and construction of the equipment involved. Since these factors may vary it is impracticable to state that for any particular type of equipment a lubricant of certain definite characteristics should always be used. Consideration should first be given to the speed of operation, the prevailing operating temperatures, the extent to which pressure may be developed between the moving parts, the means provided for lubrication and the degree to which the wearing elements may be exposed, subjecting the lubricants to contamination.

In view of the fact that certain types of machinery may function with comparative satisfaction on a wide variety of lubricants the thought may occur to the layman that perhaps this matter of definite lubrication recommendations is over-stressed. But one must realize the extent to which power consumption may be affected. It is perfectly true that virtually any good grade of oil or grease will develop lubrication, but how effectively this will result in the maximum reduction of friction will depend upon the ability of the resultant lubricating film to withstand the operating pressures, temperatures and the possibility of contamination.

So extensively has all this been studied that we feel convinced in stating that in the majority of cases for any particular type of service there will be some one specific product which will insure the most satisfactory service, by virtue of some inherent characteristic. To attain this objective, however, the Lubricating Engineer must study the details of design, the operating conditions, and the means of lubrication available in order to decide upon this so-called ideal lubricant. In fact, it may be safely said that the development of the average lubrication recommendation will depend upon these three primary factors.

To be able to thoroughly realize the relationship of lubrication to design it is essential that the lubricating engineer have an intimate knowledge of the intended function of the machinery with which he is dealing, and the manner in which this function has been anticipated by the Designing Engineer in making the plans.

The intricacy of design will be determined by the function of the machine; the hydraulic turbine, for example, although comparatively massive, must be designed in a most careful manner in order that its intended alignment



Courtesy of Ingersoll-Rand Company

Fig. 1—Showing a Cameron four-stage pipe line pump, installed in connection with Falk reduction gears. The maximum production of oil field and pipe line machinery has been assured by the care which the designing engineer has used in the study of operating conditions as related to lubrication.

may be maintained and the thrust pressure developed during operation prevented from becoming so abnormal as to cause damage to the thrust bearings.

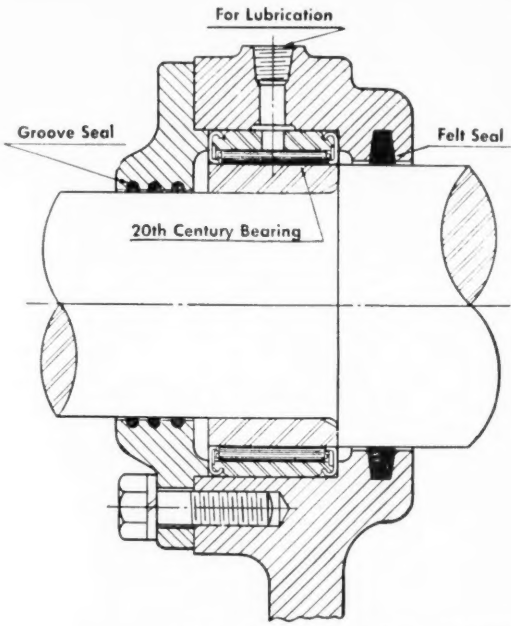
A steam pump on the other hand is normally a very simple mechanism. In consequence, it is not essential to devote any extensive amount of care to its construction, other than to insure that the moving parts fit properly, for it must be realized that the steam pump is normally operated under conditions which will not be conducive to most effective lubrication. Therefore, the bearings of a reciprocating boiler feed pump, for instance, should not be expected to show as long a life as those of a hydraulic or steam turbine.

FUNCTION OF THE DESIGNING ENGINEER

Those factors which will enter into the operation of any piece of machinery are normally taken into consideration by the Designing Engineer. If it is impossible to prevent a machine from coming in contact with abrasive foreign matter he may be justified in not giving it the same care as he would to a device which can be installed apart from dust or dirt, and the detrimental effects of water, or wide temperature variations. It is perfectly practicable, however, to design certain types of machinery, notably the electric motor and some varieties of machine tools, in such a dust tight manner as to absolutely insure maintenance of quite as effective lubrication as can be secured where these conditions do not exist. This has been materially aided by the development of the anti-friction bearing and the success achieved by the builders of such bearings in construction of dust guards and means of lubricant retention.

Design is, therefore, a criterion as to the degree of refinement essential in a lubricant. Wherever the design of bearings, gears, chains or other moving parts is such that the service will be comparatively rough, if it is impracticable to prevent drip or waste, a cheaper grade of lubricant can normally be recommended than where such conditions do not exist.

To be true, a cheaper grade of lubricant may not possess the same lubricating ability as a more highly refined product; on the other hand, the use of the latter under such conditions



Courtesy of Roller Bearing Company of America

Fig. 2—Details of a typical needle-type roller bearing. Note in particular the provisions for sealing against entry of contaminating foreign matter, and point of application for lubrication in a bearing of this type. It is highly important to prevent entry of non-lubricating abrasive materials which might lead to scoring of the bearing elements. This has been thoroughly realized bv the Designing Engineer as indicated above.

would not be economical nor an assurance of any better lubrication, due to the fact that it might become unduly contaminated, with consequent reduction in its original lubricating ability. Furthermore, were it to drip or be

wasted prematurely the first cost would not be justified.

It is erroneous to feel, however, that where original design may be such as to lead to waste of lubricants, endeavor should not be made to overcome this, if it can be accomplished without abnormal expense. This will be especially true under conditions which may cause contamination of lubricants during operation.

There are many ways by which waste can be prevented. They will depend to a large extent on the design of the equipment, the product being handled, the duty involved and the location. In the steel mill, for example, especially on certain older types of equipment, gears and bearings are comparatively exposed. There is also a good deal of dirt and sometimes water around a steel plant which may come in contact with such moving parts.

It has been proven, however, that gears can be enclosed in sheet metal housings, and bearing guards installed which will materially reduce the extent to which lubricants may be contaminated. By this prevention of contamination the durability and life of such products can be extended.

The lubricating engineer must study design from this point of view. He may, however, not always be able to prevail on his accounts to spend the money for such means of protection. It is then his duty to decide upon grades of lubricants commensurate with the operating conditions as they may prevail.

A theoretical lubrication recommendation for any specific type of machine, however, is more or less of an ideal, for it is based upon modern design and the assumption that the builders have realized the importance of lubrication and the necessity for protecting the moving parts as much as possible.

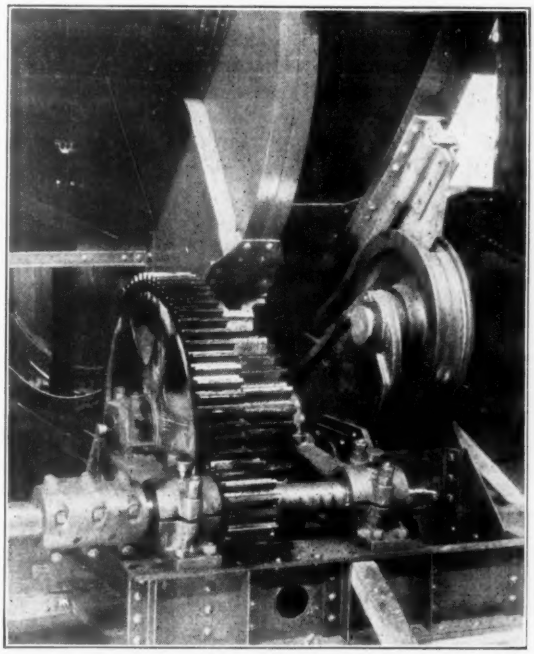
On the other hand, whereas a very high grade of grease or a filtered straight mineral oil would be adaptable to such a type of design, where an older installation is involved, the engineer should use his judgment in substituting a product which from a price point of view will be in line with the existing conditions.

It is for this reason that a working lubrication recommendation should normally include two or more grades of lubricants of varying degree of refinement; where oils are involved, however, they should be of approximately the same viscosity, commensurate with the speed, operating pressure, and the extent to which temperature variation may occur.

The operator should, in turn, realize this when in the market for such lubricants. If he is dealing with a representative of a reputable oil company these facts will be brought to his attention, the proper viscosity or body of the lubricant decided upon, and the choice between a primary and secondary grade of lubricant justified according to the operating conditions of the installation.

OPERATING CONDITIONS

A thorough understanding of operating conditions including speed, pressure, temperature and the possibility of water coming in contact with wearing parts, or the extent to which contaminating foreign matter may be prevalent, is always essential if an intelligent lubrication recommendation is to be made.



Courtesy of Newport News Shipbuilding & Dry Dock Co.

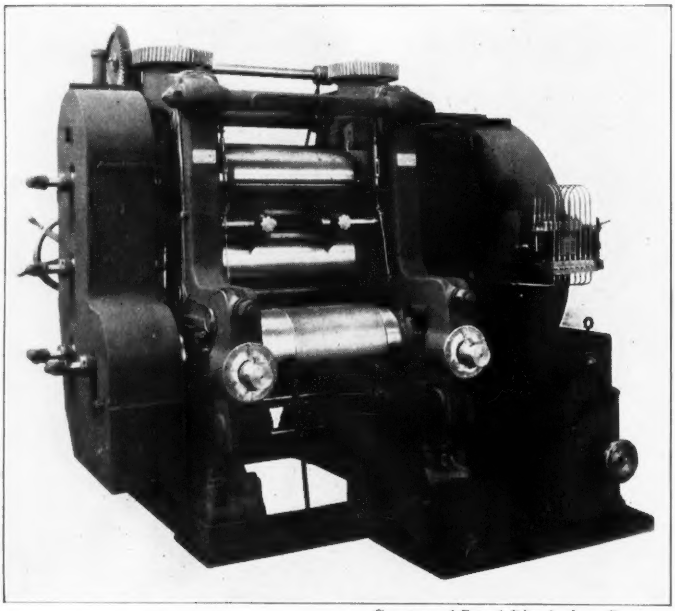
Fig. 3—The operating mechanism for a revolving car dumper is of interest by virtue of the loads which must be carried by both gears and bearings. In this type of service it may often be virtually impossible to protect lubricants against a certain amount of contamination.

As a general rule, speed and pressure must be regarded as inter-related, especially in the choice of body of an oil or the consistency of a grease.

Speed

In selecting lubricating oils for bearing service, where speed alone is considered, it will generally be practicable to vary the viscosity inversely with the speed. In other words, for high speed conditions a comparatively light bodied lubricant can be used. Lower speeds will require a heavier product. The reason for this is that the higher the speed the greater will be the degree to which the lubricant will be drawn into the clearance spaces by capillary action. The development of a constant film of lubricant within the bearing clearance space, however, will of course be contingent upon the

extent to which automatic lubrication is provided for. Obviously if oil is delivered by means of a drip feed oiler, wherein the principle is to supply just enough oil to maintain lubrication, increase in speed, unless the rate of drip of oil is increased, may result in impaired lubrication.



Courtesy of Farrel-Birmingham Company

Fig. 4—The application of the mechanical force-feed lubricator to heavy duty rolling operations has been one of the distinctive advancements in the interest of more positive lubrication of roll bearings. In the above installation provisions for housing of ball bearings and a majority of the gears are a distinct credit to the Designing Engineer.

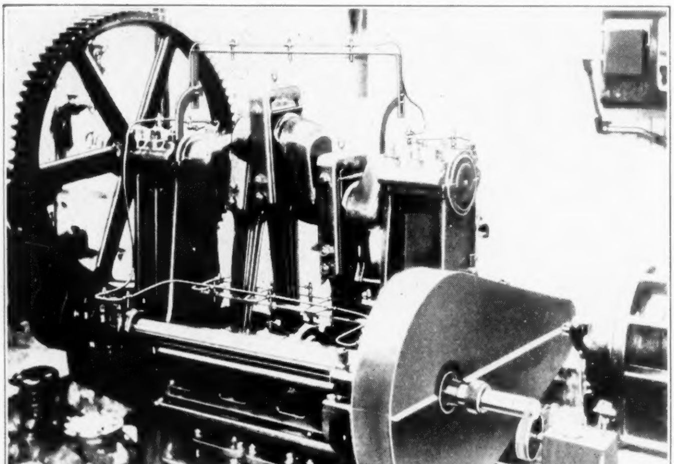
Where automatic lubrication, especially of the force-feed type, is involved, however, there will always be more oil delivered than is required to maintain lubrication. Flood lubrication will tend to materially resist the effects of pressure. This is admirably illustrated by the lubricating system of the average pressure oiled steam turbine bearing. Here, although comparatively high speeds may be involved, and bearing pressures may be fairly high, if the oil is delivered under normal turbine pressure a product of as low a viscosity as 140 seconds Saybolt at 100 degrees Fahr., will adequately maintain lubrication and insure protection of the bearings.

There is a further advantage to flood lubrication, in that the excess oil passing through the bearings will remove a certain amount of the heat developed during operation, or received from any external source. As a result, it may be said that speed leads to the development of a more positive lubricating film, due to the increased capillary action, or the extent to which the oil is drawn into the bearing. It also makes possible the use of a lighter product, which will oftentimes reduce the amount of power consumed as well as the amount of internal friction developed within the lubricant itself.

Wherever grease is to be used as a lubricant for high speed conditions it is well to remember that such a lubricant is more particularly adaptable to anti-friction bearing construction. It has been proven that if the bearing is properly designed to retain the lubricant, and a product chosen with a high degree of lubricating ability, it will insure lubrication for an extensive period of operation, with the necessity for only infrequent renewal.

It is important to remember that the anti-friction bearing should not be completely filled with lubricant, for this may not only lead to channelling of the product but also to increased power consumption, due to the drag which may be imposed upon the rolling elements.

Wherever gears, chains or other motions are involved, however, speed must be studied from the viewpoint of the extent to which centrifugal force will be developed and the lubricant thrown from the moving parts. Here, there is more relationship between speed



Courtesy of Rivett Lathe and Grinder Company

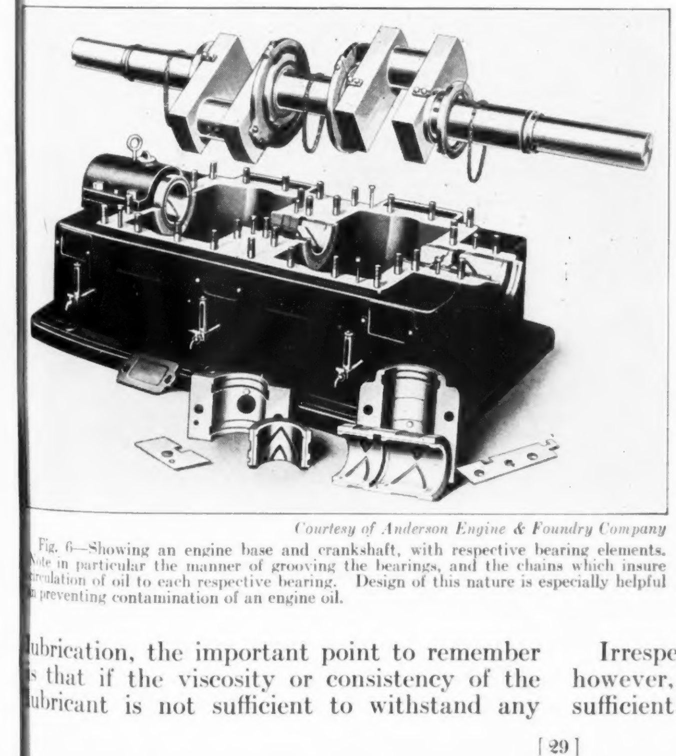
Fig. 5—Application of the Blanchard System for automatic lubrication to pumping operations and the simplicity of the piping layout is plainly shown in the above illustration. Circulation of oil under a certain amount of pressure to bearings which may be subjected to considerable pressure and perhaps wide variation in temperature is especially conducive to more effective lubrication.

and the adhesive characteristics of the lubricants. This will be especially true on exposed gears or chains. In an oil-tight gear or chain housing a comparatively fluid oil can be used, especially if it is automatically delivered to the parts and not merely carried to same by virtue of the dipping of the gear teeth or chain sprockets in the bath of lubricant. Where gears and chains are not tightly housed, however, thought must be given to the adhesive characteristics as well as the viscosity of the lubricant. It is for this reason that straight mineral petroleum products are more adaptable to such installations than compounds such as greases.

Certain of these latter, of course, have comparatively high adhesive tendencies. On the other hand, they will be more expensive and not as durable for the service involved as the straight mineral residual gear lubricants. Here again it is within the province of the lubricating engineer to study the installation and make his recommendation accordingly, explaining, of course, to the operator his reasons for determining how heavy a product should be used.

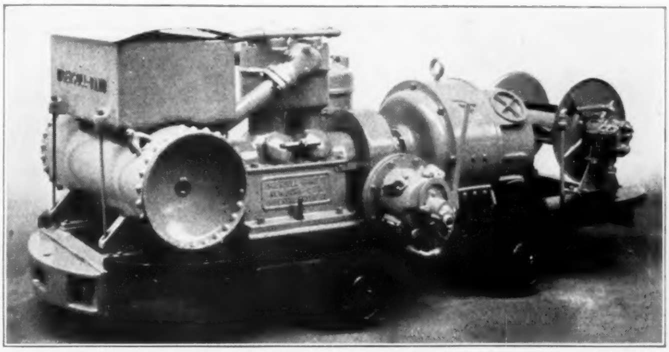
Effect of Pressure

In considering pressure alone from the viewpoint of the degree to which it may impair lubrication, the important point to remember is that if the viscosity or consistency of the lubricant is not sufficient to withstand any squeezing out action which may be developed due to the construction of the bearing, considerable damage because of lack of proper lubrication will probably follow. As a result, pressure is one of the salient factors which must be considered in the study of any lubricating problem and the preparation of a lubrication recommendation.



Courtesy of Anderson Engine & Foundry Company

Fig. 6—Showing an engine base and crankshaft, with respective bearing elements. Note in particular the manner of grooving the bearings, and the chains which insure circulation of oil to each respective bearing. Design of this nature is especially helpful in preventing contamination of an engine oil.



Courtesy of Ingersoll-Rand Company

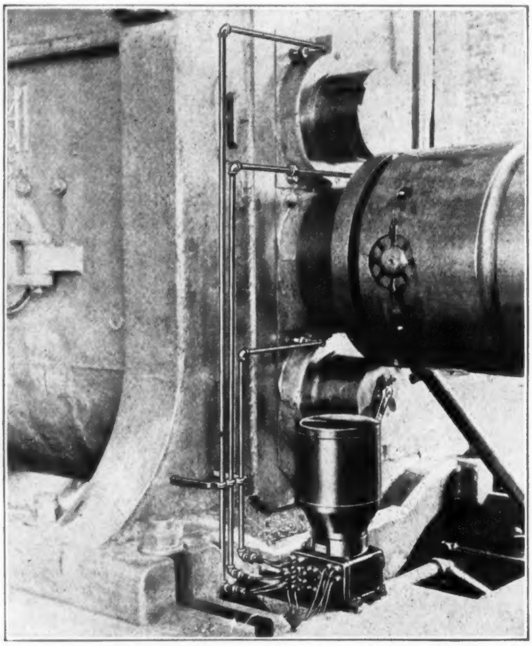
Fig. 7—One of the most interesting examples of intensive study in machine design has been the Ingersoll-Rand flame-proof mine car. Obviously, in the interest of safety and protection of moving parts, all those requiring lubrication have been most carefully studied to insure against leakage of lubrication and also entry of contaminating foreign matter.

It is evident that under average conditions the greater the existing or operating pressure between any two wearing elements, the heavier or more viscous must be the lubricating film in order to prevent metal-to-metal contact. This holds true whether bearings, gear teeth or chain link connections are involved. The logical effect of pressure will be a tendency toward squeezing out of the lubricating film from between the wearing surfaces in question. In a bearing the essential solution to this problem will be proper grooving and adequate bearing area.

On the other hand, with certain types of wearing elements the danger of impaired lubrication due to pressure can be partially prevented by enclosed construction, and operating the parts in a bath or flood of lubricant. Relative to the development of such pressures, however, it must be remembered that the period of maximum intensity is relatively brief. In other cases, pressure can be met with pressure, the lubricant being maintained within the clearance spaces under the prevailing pressure of some form of pumping device. This is, however, impracticable on open-ended bearings.

Irrespective of the means of application, however, a certain degree of adhesiveness and sufficient viscosity must be prevailing charac-

teristics of the lubricant itself. To make any other than generalized statements as to the viscosity range would be unwise. Too much will depend upon conditions of construction, operation and means of application. It will be far better to study these latter conditions in order that the severity of the duty may be realized. With such knowledge as a basis, and an understanding of what is actually involved when we speak of viscosity, etc., the problem of subsequently selecting oils or greases to function effectively should be materially simplified.



Courtesy of United American Bosch Corporation

Fig. 8—Showing a rolling mill pinion stand, equipped for force-feed grease lubrication. The application of the Bosch Lubricator and the piping which is necessary for transmission of grease to the bearings is another instance of cooperative study between the designing engineer and the lubrication specialist.

It is practicable to use either oil or grease for the lubrication of many wearing elements. The ultimate factor will involve the type of lubricating equipment provided, and the operating conditions such as speed and bearing pressures, and details of construction such as manner of grooving.

By virtue of the size, duty, and bulky nature of the moving parts of the average machine involving high pressures, it has been deemed advisable in many cases to provide for some form of positive, automatic lubrication. Greater convenience should thereby result, with frequently marked savings in labor due to reduction in the amount of attention necessary. Typical examples will be rolling equipment in the steel mill, the metal press in the automotive plant, the cement kiln and the news or textile press, or the milling machine.

In virtually any piece of machinery where pressure may prevail it is important to remember that it is the "operating pressure" which must be considered. When the rolling mill or metal press, for example, is idling, the pressure which may exist between the teeth of its gear trains, or upon the bearings of certain of its shafting may not be abnormal. When idling there should, therefore, be no problem in the maintenance of lubrication on such equipment.

When under operation, however, the pressure to be exerted upon the raw materials in the formation of finished or semi-finished products will react back through practically all the moving elements of the machine. Not with the same intensity in every case, to be sure, for this will depend upon the size or relative importance of the parts involved. But, in general, such reactionary or back pressures will be considerably in excess of the idling pressures, and hence they will be a potential cause of lubricating difficulties.

As a result, it is the operating pressure which must be taken into account when selecting lubricants for any particular type of heavy duty machinery, or its respective wearing elements. The purpose, of course, must be to use lubricants which will be of such body and adhesive ability as to effectively withstand being squeezed out from between gear teeth, chain link connections, or bearings and shafting. These characteristics in the lubricants must be considered from the viewpoint of maximum pressure involved.

Of course, on certain machinery this may result in abnormal internal friction within some lubricants when the machinery is idling, but it is far more important to prevent metal-to-metal contact under high operating pressures and thereby preclude the development of abnormal wear, than to reduce power consumption during idling. This is expecially true inasmuch as such machinery to develop maximum efficiency should idle as little as possible.

Temperature

The influence which temperature will have upon a lubrication recommendation will depend upon the extent to which the operating temperatures may vary. As a general rule, this factor must be considered in deciding upon the manner of preparation of a grease or the melting point of any such product, or the viscosity of an oil, wherever conditions may be deemed to be in any way abnormal.

High temperature operation is worthy of special consideration. High temperature conditions will usually impose a greater duty upon a lubricant than any other phase of operation. In connection with this matter of temperature, it must be remembered that the inherent possi-

bility of development of solid friction will always be present. Solid friction between any two surfaces in motion with respect to one another implies the presence of heat, which is invariably developed by the occurrence of friction. It is the function of lubrication to eliminate solid or metallic friction, supplementing it with fluid friction, which will normally be of far less intensity.

Where high operating temperatures may prevail the proper viscosity or body of a lubricant must be given all the more careful attention, for viscosity will vary inversely with temperature. In other words, the higher the operating temperature the greater will be the tendency for the body or viscosity of the lubricant to be reduced. If the original viscosity is not sufficiently high to allow for this reduction, the increased fluidity may lead to impairment of the lubricating film to such an extent as to actually cause metal-to-metal contact.

This will be especially apt to occur under comparatively high pressure. It is for this reason that the viscosity-temperature conversion chart should be studied in connection with the formulation of a lubrication recommendation for high temperature operation. By the use of such a chart one can readily determine the operating viscosity of any lubricating oil at the prevailing temperature of operation, knowing the viscosity at some two points such as 100 degrees and 210 degrees Fahr., according to the prevailing marketing specifications. Normally lubricating oils of a viscosity up to approximately 800 seconds Saybolt at 100 degrees Fahr., are specified at this particular temperature. The viscosity of heavier lubricants, however, is usually stated at 210 degrees Fahr.

While the use of an oil of sufficient viscosity to meet the operating conditions will, of course, result in more effective lubrication, it will also prove of decided value in reducing the amount of power or energy required to move the working elements. In addition, any tendency towards the development of abnormal frictional heat will be reduced. All this will lead to improved lubrication, for it will enable the oil to perform its function more perfectly, maintaining the proper lubricating film under all conditions, by virtue of its viscosity or body.

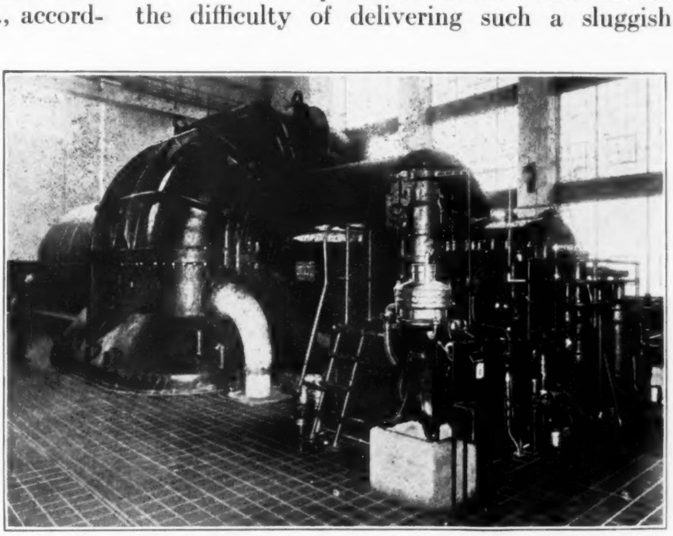
The Importance of Viscosity

It has already been stated that viscosity varies inversely with the temperature. Under certain conditions this is an asset, for it may permit of one lubricant serving a number of points of varying external temperatures, provided the size of the wearing elements and the pressure exerted are taken into account when the lubricant is originally selected.

On the other hand, the mistake should never be made of regarding the viscosity at say 100 degrees Fahr., as of sole importance, for an oil which might be of adequate viscosity at that temperature might be too light to meet an operating temperature range at say 150 degrees Fahr. As a result, there is a direct tie-up between power consumption, friction and temperature.

Low Temperature Operation

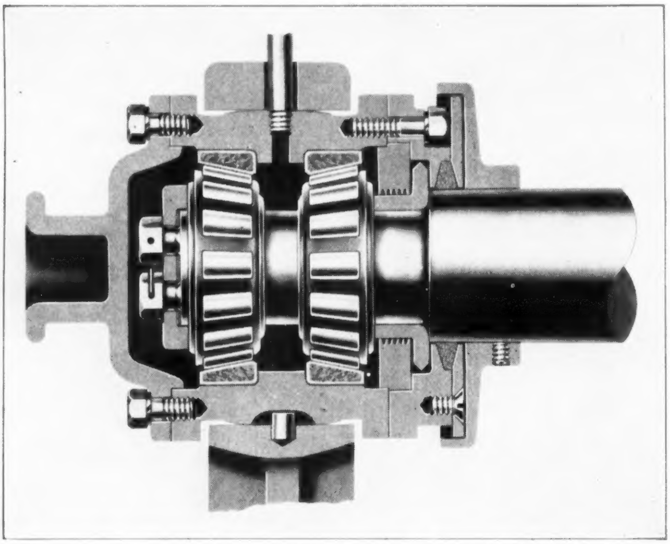
It is just as important to study the operating viscosity of an oil where low temperatures are involved as when high temperatures are to be met. In case of low temperature operation, however, there will be less possibility of metal-to-metal contact between the wearing elements. Under such conditions we must be more concerned with the possibility of developing abnormal internal friction within the body of the lubricating film itself. This would, of course, lead to increased power consumption. If allowed to become abnormal it might even render the machine inoperative. There would also be the difficulty of delivering such a sluggish lubricant to the moving parts on starting. Should this latter prevail for any length of time, metal-to-metal contact might occur until the temperature of the machine is raised sufficiently to expedite ready flow of the lubricant.



Courtesy of DeLaval Separator Company

Fig. 9—Steam turbine operation calls for the most careful study of lubrication. It is absolutely essential that bearings be most positively protected and this can only be accomplished by continuous circulation of oil which is kept at a high degree of purity. The centrifugal purifier is decidedly beneficial in this regard and the manner of its application to a typical turbine installation is shown above.

LUBRICANT CONTAMINATION MUST BE PREVENTED



Courtesy of Timken Roller Bearing Company

Fig. 10—Showing a typical application of Timken Bearings to the couch roll of a paper machine. The means for preventing loss of lubricant or entry of contaminating foreign matter at the inboard end of this bearing are particularly interesting. It is always important to remember that an expensive bearing installation justifies most careful study in regard to protection of lubricants.

Abnormal contamination of lubricants may defeat the objective, however carefully the recommendations may have been made. In certain industries contamination will be more prevalent than in others. It will all depend upon the provisions for storage, the operating conditions to which machinery may be subjected and the nature of the materials being handled. In the steel mill and cement industry there will be certain types of operation where a decided load will be imposed upon lubricants in general. Comparatively high temperatures will prevail in connection with much of the equipment, as for example, in the steel rolling mill, or on kiln trunnion bearings; elsewhere, as in the yard, the bearings, gearing and wire rope of cranes will be exposed to the weather; and furthermore, dust, dirt, flying scale and water may all be more or less encountered by virtually all equipment dependent upon the location and duty involved.

How to protect lubricants under such conditions so that they may function with greater satisfaction will often present a distinct problem. Those characteristics of lubricants which should be investigated when making initial selection for various types of operation have been discussed in detail in previous issues of "LUBRICATION." If properly considered there will be assurance that high temperature and moisture conditions will be met with greater satisfaction. Viscosity, pour test or flash point, for example, will be of decided advantage in denoting how an oil will function at certain temperature extremes, and what its body will be. They will not indicate, however, as to just how an oil will resist contamination when exposed to foreign matter. Where this latter is involved, the problem will be to study storage and handling conditions as well as the construction of wearing elements, to determine the most suitable type of guards, containers, or housings, and to establish rules for handling.

Possibility of contamination in storage will largely depend upon the location of the oil house or oil room and the nature of its construction. If located adjacent to the yard hoist, or in a corner of the power plant building, where doors or windows must be left open, or when they are poorly screened, air drafts may often cause circulation of considerable abrasive dust or dirt. It will be only necessary to leave oil or grease in open containers for a short time under such conditions to result in absorption of whatever dust may settle on the surfaces. Inasmuch as virtually any type of dust is abrasive, lubricants which have been thus contaminated will very frequently tend to promote wear, by virtue of their dust content, rather than leading to its reduction by reason of their lubricating ability.

To prevent all this lubricants should be stored in enclosed tanks or drums, with tightly fitting covers on all containers with removable heads. Where oils are consumed in sufficient volume to warrant bulk storage, large permanent tanks should be installed into which the contents of shipping drums can be emptied, or which can be filled directly from tank cars or trucks. Storage tanks of this nature are sealed to prevent leakage of oil or entry of air. They are usually equipped with measuring pumps, return drains, gauge connections and suitable covered hatches for filling or inspection.

If there is further provision to draw oils only into clean distributing containers, and in just sufficient amounts to cover immediate requirements, contamination at the point of distribution can be even more positively prevented.

Fluid oils can be more easily kept free from contamination during storage than greases, or gear or wire rope lubricants. These latter will

very frequently be so inert, and used in such comparatively small quantities, that storage in the shipping drums or barrels will prevail. With many steel containers the top is so constructed as to be replaceable. As a result it can be readily removed when a supply of lubricant is needed, and just as easily replaced to prevent the possible entry of dust or dirt.

Where greases are involved, it must be remembered that the possibility of water contamination must always be guarded against. Certain greases, according to their nature and the purpose for which they are intended will contain more or less water. As a general rule, this is an accurately determined quantity. As a result, should any more gain entry, there will be possibility of some greases becoming decidedly altered from both a physical and chemical nature.

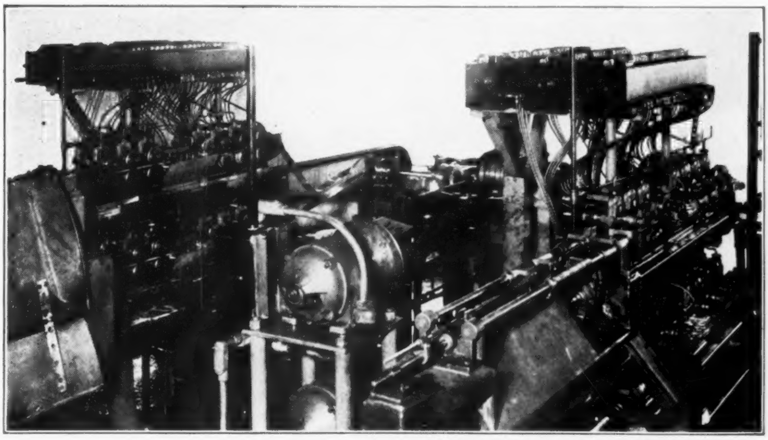
Handling of greases and other heavy or more or less inert lubricants must also be given careful consideration. In view of their consistency they must usually be scooped from the containers. This can only be done by hand. During such a procedure there will be considerable possibility of dirt gaining entry, especially if scoops or paddles have not been kept where they could not gather dust. Dirt may also fall off from dirty clothing.

It is virtually impossible for one to keep clean around certain parts of many plants; as a result all should not have access to lubricant storage. Far better will it be to detail a certain part of plant personnel to work only in connection with lubricants and lubrication. They at least can keep cleaner than many of the others; in addition the keeping of lubrication records, and maintenance of economy in issuing the various products can be practiced. Where a separate space or an individual building is reserved for bulk storage of lubricants, the keeping of records is highly essential.

After lubricants have been issued to the several departments, protection against contamination must be observed by the individuals involved with their application. Very often, where gears may run exposed, or only partly enclosed, it will seem to be fruitless to insist on undue care in application of lubricants. In many industries the average gear is usually comparatively massive and built for rugged service. Its teeth, however, can be protected by proper lubrication, and the less contaminated the lubricants, or the more dust-proof the casing, the more effectively will wear be reduced.

Bearing wear will oftentimes be more serious than wear on gear teeth. Furthermore, scoring or wear in a bearing will usually develop more rapidly, for it will normally not require as much abrasive matter in the lubricating film to damage a bearing as a gear tooth. For this reason bearings are usually constructed so as to more readily prevent entry of dust, dirt or scale. With sleeve bearings of the grease lubricated type, the collar of grease at the exposed ends will often serve as a very good seal. How much abrasive foreign matter may gain entry will largely depend upon the condition of the lubricant when applied, and the means of delivery to the bearing.

Where automatic lubrication is involved, as for example, by use of the ring oiler, renewal of oil will only be necessary at infrequent intervals. During operation the point of application should be sealed by a suitable dust-tight cap or plug. With the sight-feed oil cup, on the other hand, which is so extensively used in the average engine room, or on certain crane bearings, daily filling may be necessary, dependent upon the extent of operation and the capacity of the cup. This will require the keeping of an oil container at hand. If this latter is properly covered, or kept under the hood of an auxiliary storage tank, the purity of the contents can be preserved. If, however, it is allowed to remain open and exposed to dust or dirt, very soon the oil therein may become akin to a grinding compound.



Courtesy of McCord Radiator & Manufacturing Company

Fig. 11—Showing application of a battery of six mechanical force-feed lubricators for serving the bearings on an automatic high speed tube-forming machine. Controlled lubrication on this unit is of particular importance in the interest of continued production. The manner in which the designing and installation engineers have cooperated in handling of piping from these lubricators is of particular interest.

Application of Steam Cylinder Oil

The means provided for the introduction of a steam cylinder oil into the steam line is of considerable importance in connection with subsequent development of effective lubrication of the steam cylinders of the average reciprocating engine, pump or compressor. In fact, proper lubrication of cylinders will depend quite as much upon the method of application as it will upon the characteristics of the oil used. As a result, both should be studied with respect to one another, and final decision as to the type of oil arrived at only after due consideration of the steam pressure and temperature, the quality, the degree of superheat, the type of lubricator involved, the design, and the location of the atomizer in the steam line.

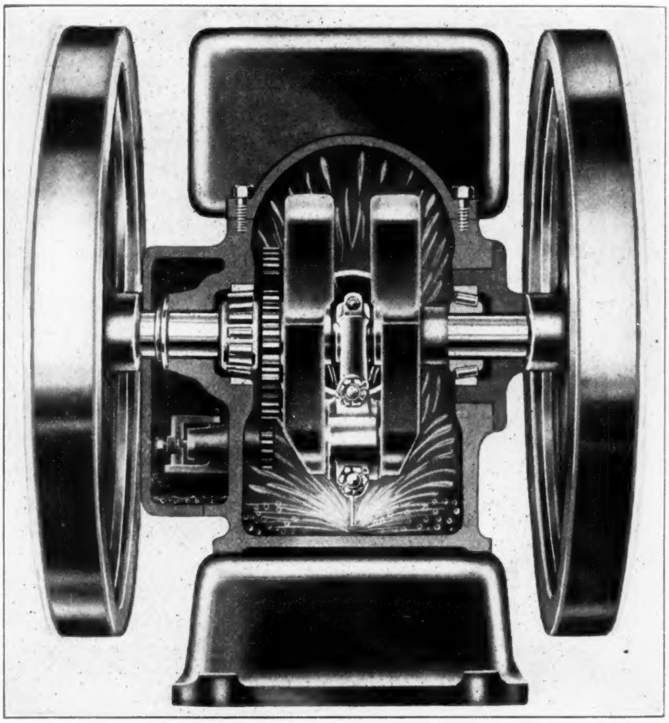
The oil should be considered primarily with respect to its viscosity or body, and the amount of fixed or fatty oil compound which it should contain to develop a most effective lubricating film on the cylinder walls, to resist the washing tendency of moisture in the steam, due to original quality or cylinder condensation.

Actual lubrication of a steam cylinder is brought about by the steam. It is, therefore, highly essential that the oil be delivered to this latter in a manner conducive to thorough atomization, and complete, uniform and constant dispersion of the particles of oil be made throughout the body of the steam, prior to entry into the valve chest and cylinder. This can be accomplished by using a properly designed atomizer, located from two to six feet above or in back of the throttle valve, in conjunction with a positive feed mechanical or hydrostatic lubricator.

Provided conditions of application are mechanically correct, the steam should be thoroughly impregnated with sufficient oil at a rate of but a few drops per minute, insuring not only economy of oil, but also adequate protection of valves, valve seats, cylinder walls and piston rings.

It is highly advisable to reduce the rate of oil feed as much as possible wherever use is to be made of the exhaust as a direct heating medium. Otherwise, unless suitable oil strainers are installed, there will be considerable possibility of an appreciable amount of oil being carried over by the exhaust, to contaminate make-up feed water, or form an insulating medium on the steam side of heating coils, to reduce the subsequent rate of heat transfer.

By reason of the fact that compound in a



Courtesy of Witte Engine Works

Fig. 12—A most interesting development in internal combustion engine design has been brought out by Witte. The lubricating system is shown above. It is entirely automatic. This particular engine is a completely self-contained power plant, the cooling water being contained in a large hopper at the top, cylinder oil in the crankcase and fuel in the subbase.

cylinder oil will directly affect the ability of such a product to separate from water, present day practice in the manufacture of high grade steam cylinder lubricants is to reduce the amount of compound and to use animal fats of very high quality. Oils composed of high grade ingredients will develop a lather or emulsion of adequate lubricating ability in as nearly as possible the right amount to protect the moving parts of the steam end subjected to the washing action of wet steam. Furthermore, the nature of the emulsion, coupled with the fact that it is not present in excess, will frequently enable direct use of the exhaust, due to the comparatively low oil content.

The extent to which separation of such matter from exhaust steam can be effected will depend upon the manner in which the oil is atomized and dispersed through the steam by the lubricating system. In general, the more complete the atomization the more difficult will it be to separate an oil emulsion from water. A dual thought is, therefore, involved

in the selection of steam cylinder oil to meet wet steam conditions, where the exhaust is later to be used for heating purposes. Here consideration of the compound content is of great importance and should be carefully studied not only from its relationship to the above conditions, but also as to the extent to which it will enable oil delivery to be reduced as low as possible, commensurate with the requirements of the unit involved.

Effect of Pressure

The effect of steam pressure upon atomization requires consideration of the viscosity or body of the oil. In general, the higher the pressure, the more rapidly can atomization be accomplished. This is an important point to remember where the lubricator inlet or atomizer may be located within approximately three feet of the throttle valve. Inasmuch as it is desirable for the oil to be completely atomized by the time it reaches the latter, the relation of pressure to viscosity must also be understood. The higher the pressure, the greater the temperature; in other words, the greater the viscosity-reducing effect. An oil of say 135 seconds Saybolt viscosity at 210 degrees Fahr., will therefore become thinner and more readily atomized by steam at 150 pounds pressure than by steam at 125 pounds.

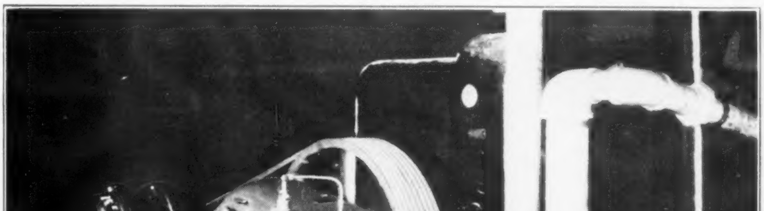
In consequence, pressures of 150 pounds or above will permit the use of oils of higher viscosity, particularly where application is not too close to the throttle. With lower pressures, on the other hand, a similar installation would probably function best on an oil having a Saybolt viscosity around 120 seconds at 210 degrees Fahr. In any type of service requiring consideration of atomization speed, however, it is essential to remember that ability to atomize will vary directly as the amount of compound used. Lower viscosity oils containing from 6 to 10 per cent of compound such as degras or tallow can, therefore, be expected to be best suited to moderate pressure wet steam conditions.

Experience has indicated that filtered cylinder oils will also atomize more readily than unfiltered stocks. Where quick atomization is essential, as for example, should it be necessary to deliver oil directly into the steam cylinders instead of the steam line, due to structural conditions, a filtered, compounded oil would be the proper product to use, unless, of course, superheat is involved, when the straight mineral oil is often quite suitable.

Means of Application

Delivery of cylinder oils can be most positively brought about by use of a pressure type of lubricator, in conjunction with a suitably designed atomizer or spoon. The former enables accurate control of flow, the latter even distribution into the steam line. Atomizer design will frequently be given so little thought that it is considered advisable to discuss this in detail. Furthermore, even where the design and construction may be correct, careless installation may prevent the atomizer from serving its intended purpose, frequently to result in impaired lubrication and waste of cylinder oil.

In considering the point and manner of installation, it is important to remember that an atomizer should be so located in the steam line as to be subject to straight line flow of steam without the possibility of surging, otherwise there might be a tendency for the oil to be thrown to the sides of the steam pipe. This would be particularly apt to occur should there be any bends between the atomizer and the valve chest. Obviously, oil thrown to the sides of the pipe would cease to be atomized, therefore, it could not function to best advantage in subsequent lubrication of the valve chest and cylinder surfaces. Normally it might be expected to be wasted, causing possible trouble



Courtesy of Ingersoll-Rand Company

Fig. 13—An air-compressor installation with a Texrope drive. The simplicity of this installation is distinctive. Note the location of the lubricator on the side of the compressor.

by accumulation and carbonization in low parts of the cylinder.

Steam cylinder oils can be most effectively applied by using some form of atomizer which is inserted permanently into the steam pipe. Attached to such an atomizer, adjacent to the outside of the pipe, a check valve can be installed to assure positive delivery of oil into the pipe. The spoon type of atomizer is one of the preferred designs. It will normally involve a nipple or short piece of pipe of the same diameter as the discharge from the lubricator. It should be of such a length that when inserted into the steam pipe it will extend slightly beyond the center line. By threading along the entire length the atomizer can be screwed directly into the tapped hole in the steam line, leaving sufficient stock exposed for attachment of the lubricator fitting to the protruding end.

The name is applied due to the fact that the top side of such an atomizer is cut away to develop a spoon shape, the tip being turned up slightly. Along the bottom, or so-called bowl of the spoon, one or more slots of perhaps 1/16 to 1/8 inch width should be cut, parallel to the axis, from one to two inches in length dependent upon the pipe diameter. To insure stability these slots should commence about half an inch in from the tip. Care should be taken when installing a spoon type atomizer, to make sure that the cut-away portion faces the direction of steam flow and that the slots are directly in line with the latter. This will insure most complete atomization for the oil as it flows into the bowl of the spoon and over the slots. It will be carried by the steam through the latter in a fan-shaped spray. To guard against improper installation the top or cut-away side of the atomizer should be plainly marked on the outside. It is important to remember that if such a device is installed upside down, oil will simply drip into the steam line, perhaps to be swept to the walls with little or no atomization.

If it is desired to avoid cutting away any of the stock in making an atomizer, perforations can be used instead. This type of device has also been found to give very satisfactory atomization. External threading should be done just as suggested for the spoon type device. The end of a perforated atomizer, however, should be plugged to prevent oil drip should an excess be delivered by the lubricator, although it is practicable to close the end by using a sufficiently long nipple and screwing it into the steam line until it touches firmly against the opposite side of the pipe.

Perforations in the form of 1/16″ to 1/8″ holes should be drilled axially through both walls of the nipple, over a distance of perhaps two-thirds the diameter of the steam line. Experience has indicated that atomization is improved if the top holes or those furthest away from the steam chest are somewhat larger than the opposing holes. To insure that such an atomizer is always properly installed, the exterior should be plainly marked to show the line of location of the larger holes. Care should be observed to locate these directly in the line of steam flow, otherwise atomization might be reduced due to the steam having to pass through the holes at an angle. The greater this angle, obviously, the less effective the atomizing action would become. Furthermore, this might ultimately lead to the holes becoming stopped up with carbonaceous matter.

There are, of course, a number of other types of so-called atomizers which are also used to some extent. One noteworthy design involves a semi-perforated type, wherein the topside only is drilled, oil flowing into it from the lubricator discharge along the lower part. In this type the end is not plugged and normally the nipple should not extend beyond the center line of the steam pipe. Atomization is brought about by the steam passing through the holes on the top side, to impinge upon the oil within and make a double turn, in theory, carrying the oil out of the end in the form of a spray.

Another type has the end of the nipple drawn down to form an orifice of perhaps 1/8″ diameter, oil dripping out of this latter to be acted upon by the steam. As with any dripping device, however, accumulation of oil in the body of the nipple may lead to carbonization and ultimate stoppage, especially where high temperature dry steam may be involved.

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